SMAST University of Massachusetts Dartmouth
The School for Marine Science and Technology

Technical Memorandum

FINAL REPORT

Water Quality Monitoring and Assessment of the Nantucket Island-Wide Estuaries and Salt Ponds 2010

To:

David Fronzuto
Town of Nantucket
Marine Department
37 Washington Street
Nantucket, MA 02554

From:

Brian Howes, David White and Roland Samimy
Coastal Systems Program
School of Marine Science and Technology (SMAST)
University of Massachusetts-Dartmouth
706 South Rodney French Blvd.
New Bedford, MA 02744

The Technical Memorandum is organized as follows:

1. Overview
   - Background
   - Need for a Monitoring Program

2. Summary of Sampling Approach in designated estuaries and salt ponds:
   - Nantucket Harbor
   - Madaket Harbor
   - Long Pond
   - Hummock Pond
   - Miacomet Pond
   - Sesachacha Pond

3. Results of Sampling: Summary of Water Quality Results
   - Review of and comparison to historical data

4. Trophic State: Water Quality/Eutrophication Status

5. Recommendations for Future Monitoring

Overview

Background: Coastal salt ponds and estuaries are among the most productive components of the coastal ocean. These circulation-restricted embayments support extensive and diverse plant and animal communities providing the foundation for many important commercial and recreational fisheries. The aesthetic value of these systems, as well as the freshwater ponds of a town, is also significant to both residents and the tourist industry alike. Maintaining high levels of water quality and ecological health in these aquatic systems (fresh and marine) is fundamental to the enjoyment and utilization of these valuable resources for all coastal communities.

Nutrient over-enrichment is the major ecological threat to water quality in the salt ponds and embayments within the Town of Nantucket, primarily via ecological degradation which results when nutrient loading exceeds the assimilative capacity (also called critical nutrient threshold) of the system for new nutrient inputs. Of the various forms of pollution that threaten coastal waters (nutrients, pathogens and toxics), nutrient inputs are the most insidious and difficult to control. This is especially true for nutrients originating from non-point sources, such as nitrogen and phosphorous transported in the groundwater from on-site septic treatment systems. On-site septic treatment systems are the primary mechanism for waste disposal within the Madaket Harbor/Long Pond, Hummock Pond, Miacomet Pond and Sesachacha Pond watersheds. Nantucket Harbor is in a somewhat different situation as the watershed to that system is almost entirely sewered. Nevertheless, the nutrient characteristics and ecological health of that system must be monitored given the shellfish fishery that depends on the water quality of Nantucket Harbor. Since nitrogen and phosphorous is a natural part of estuarine and pond systems, it is important that management allow for the natural capacity of these systems to absorb watershed nutrient inputs. Through the coupling of monitoring data to

the Massachusetts Estuaries Project (MEP) watershed loading analysis developed in collaboration with the Coastal Systems Program (CSP), the most cost-effective management strategies can be found to protect these valuable aquatic environments.
Need for a Monitoring Program: Conserving and/or restoring the environmental health of coastal embayments and freshwater ponds is achievable, but only through proper management of the waters and watersheds to each. Managing environmental health requires a quantitative understanding of the biological and physical processes which control nutrient related water quality within a specific basin and the role of watershed inputs in the nutrient balance of the receiving waters. An essential step in managing these fresh and saltwater systems is to monitor their water quality. The results of a long-term monitoring effort are needed to determine the status and trend of ecological health of each system to assess the need for management action and when coupled with higher-end ecological data to support the development of site-specific management plans.

Water quality monitoring of Nantucket's fresh and saltwater systems should focus on summer-time conditions as the warmer months typically have the lowest water quality conditions, which are the target of resource management. The Town of Nantucket has a long history of monitoring of its aquatic systems generally by the Nantucket Marine Department to support the protection and management of the natural resources of the Town of Nantucket. This effort has also allowed analysis by the Massachusetts Estuaries Project, tasked with determining the estuary specific nutrient thresholds for restoration/protection of all the coastal systems of southeastern Massachusetts inclusive of Nantucket and Martha's Vineyard.

Water quality monitoring programs can also maximize the value of their results by structuring their sampling and analysis program such that results can be cross compared to water quality monitoring data collected throughout the region. In this manner, inter-ecosystem comparisons can be made to better assess system health/impairment and function and formulate appropriate nutrient management strategies. This allows individual towns to directly benefit from lessons learned throughout the wider region.

Summary of Sampling Approach

Monitoring Project Team: To address the present nutrient related ecological health issues of the salt ponds and embayments within the Town of Nantucket and to provide necessary information with which to develop policies to protect and/or remediate these systems with regard to nutrient inputs, a long-term municipally coordinated monitoring effort was established and coordinated through the Nantucket Marine Department in early 2000 which continued through 2007. The program was interrupted in 2008 and 2009. In 2010 it was determined that the Nantucket Island-wide Water Quality Monitoring Program should be resumed with support from the Coastal Systems Program at the University of Massachusetts-Dartmouth, School for Marine Science and Technology (SMAST). The Coastal Systems Program has also been responsible for the development and coordination of the majority of the estuarine and pond water quality monitoring across southeastern Massachusetts, Cape Cod and the Islands as well as the analysis of all the samples collected and synthesis of the resulting water quality

data. A such, the CSP is able to leverage this comprehensive water quality database to further evaluate results obtained from the Nantucket Island-wide monitoring program.

CSP scientists focused primarily on the analysis of samples collected from the effort and data analysis while the Nantucket Marine Department focused primarily on field sampling and data collection on physical parameters. Both participated in the compilation of field and laboratory data to provide an ecological overview of water quality conditions within each of the systems monitored. The goals of the monitoring program were to:

(1) determine the present ecological health of each of the main salt ponds and estuaries within the Town of Nantucket,

(2) gauge (as historical data allows) the decline or recovery of various salt ponds and embayments over the long-term (also part of TMDL compliance), and

(3) provide the foundation (and context) for detailed quantitative measures for proper nutrient and resource management, if needed.

This latter point (3) is critical for restoration planning should a system be found to be impaired or trending toward impairment.

Water Quality Program Description: Sampling took place during the warmer summer/early fall months (May-October) of 2010, the critical period for environmental management. Samples were collected from 6 systems (Figures 1, 2, 3, 4 and 5) and 6 streams on dates ("events") following the schedule presented in Table 1. The Nantucket Marine Department oversaw the sampling and all samplers who were involved were given refresher "training" by CSP staff to meet QA requirements.

The physical parameters measured in the estuaries included: total depth, Secchi depth (light penetration), temperature, pond and estuary state, general weather, wind speed and direction, and dissolved oxygen levels. Laboratory analyses for estuaries included: salinity, nitrate + nitrite, ammonium, dissolved organic nitrogen, particulate organic carbon and nitrogen, chlorophyll *a* and pheophytin *a* and orthophosphate. For freshwater streams parameters included: specific conductivity, nitrate + nitrite, ammonium, dissolved organic nitrogen, particulate organic carbon and nitrogen, chlorophyll *a* and pheophytin *a,* orthophosphate and total phosphorus. In addition, 14 sets of field duplicates were taken as part of the field sampling protocol for QA analysis. Data were compiled and reviewed by the laboratory for accuracy and evaluated to discern any possible artifacts caused by improper sampling technique.

Month	Nan. Har.	Madaket	Sesach.	Miacomet	Hummock	Long	Streams
Jan							
Feb							
Mar							
April							
May	May 18	May 20	May 26	May 26	May 25	May 19	
June	June 2, 17	June 3, 15	June 24	June 24	June 29	June 17	June 28
July	July 1, 15, 30	July 16, 27	July 26	July 26	July 28	July 29	
August	Aug. 13	Aug. 12, 30	Aug. 26	Aug. 26	Aug. 27	Aug. 11	
September	Sept. 1, 14	Sept. 13	Sept. 23	Sept. 23	Sept. 28	Sept. 15	
October	Oct. 21						
November							
December							
Totals	**10**	**8**	**5**	**5**	**5**	**5**	**1**

Table 1. Sampling Schedule for 2010 Nantucket Water Quality Monitoring Program

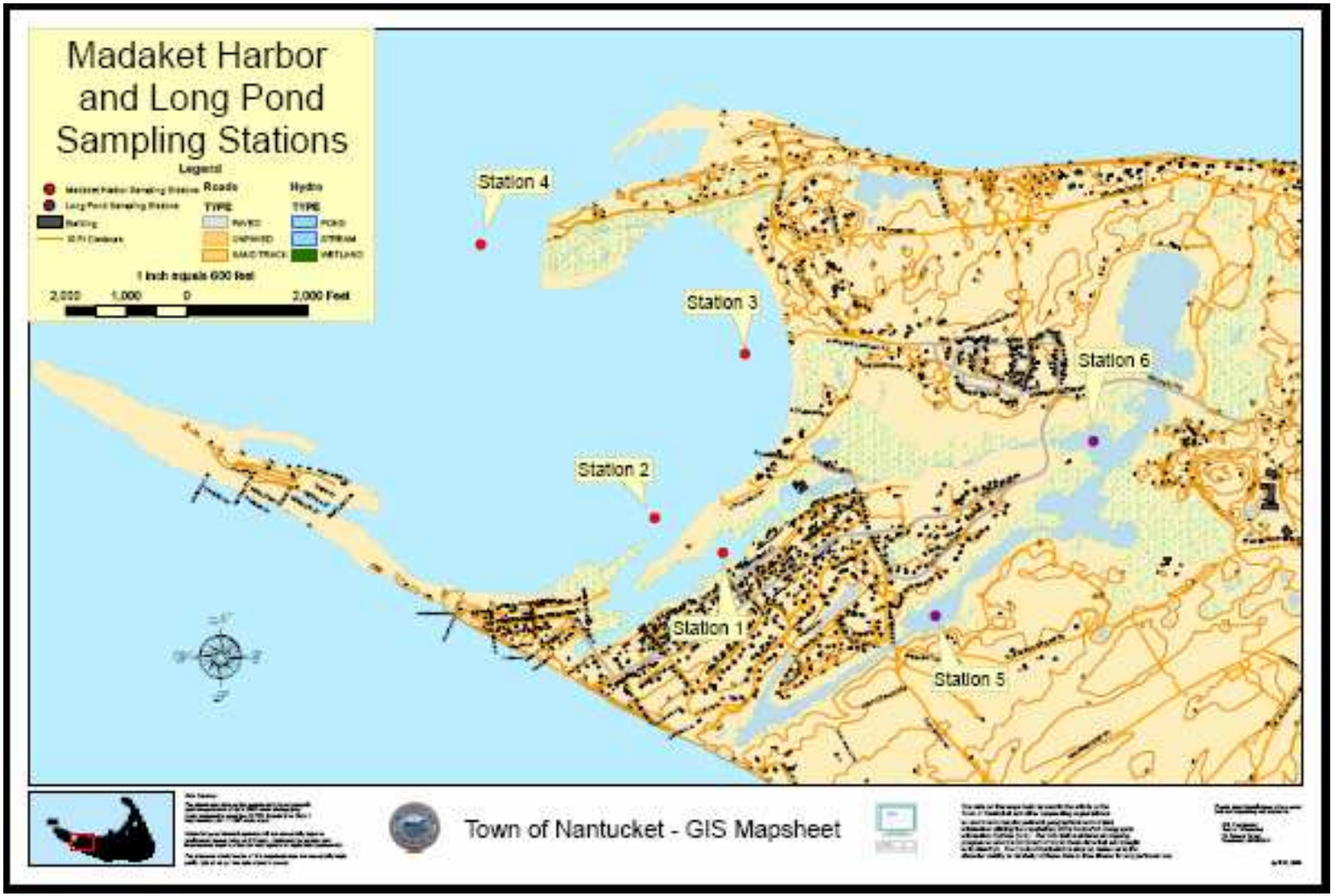

Figure 1. Madaket Harbor and Long Pond sampling stations 2010.

Figure 2. Nantucket Harbor sampling stations 2010.

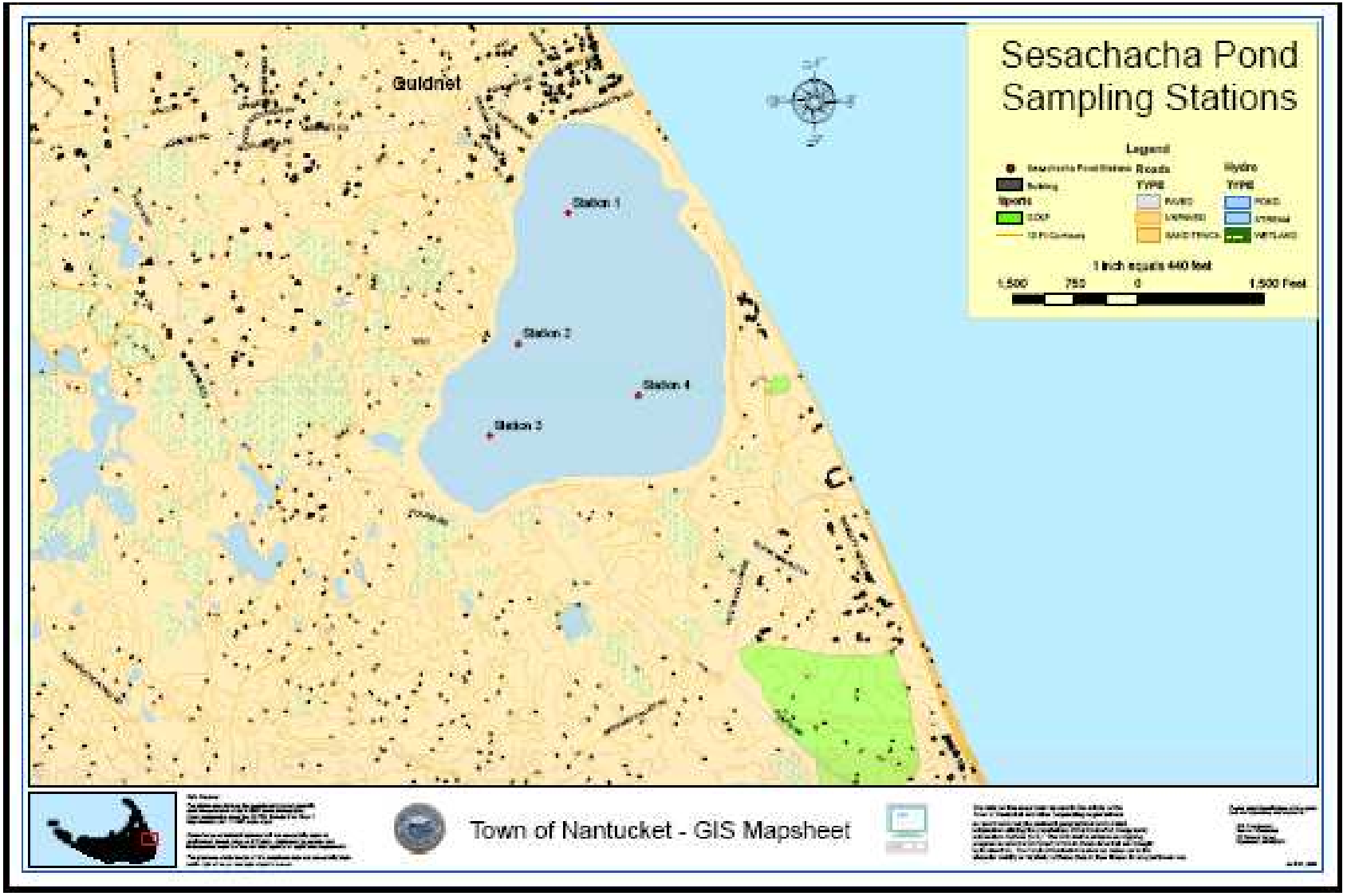

Figure 3. Sesachacha Pond sampling stations 2010.

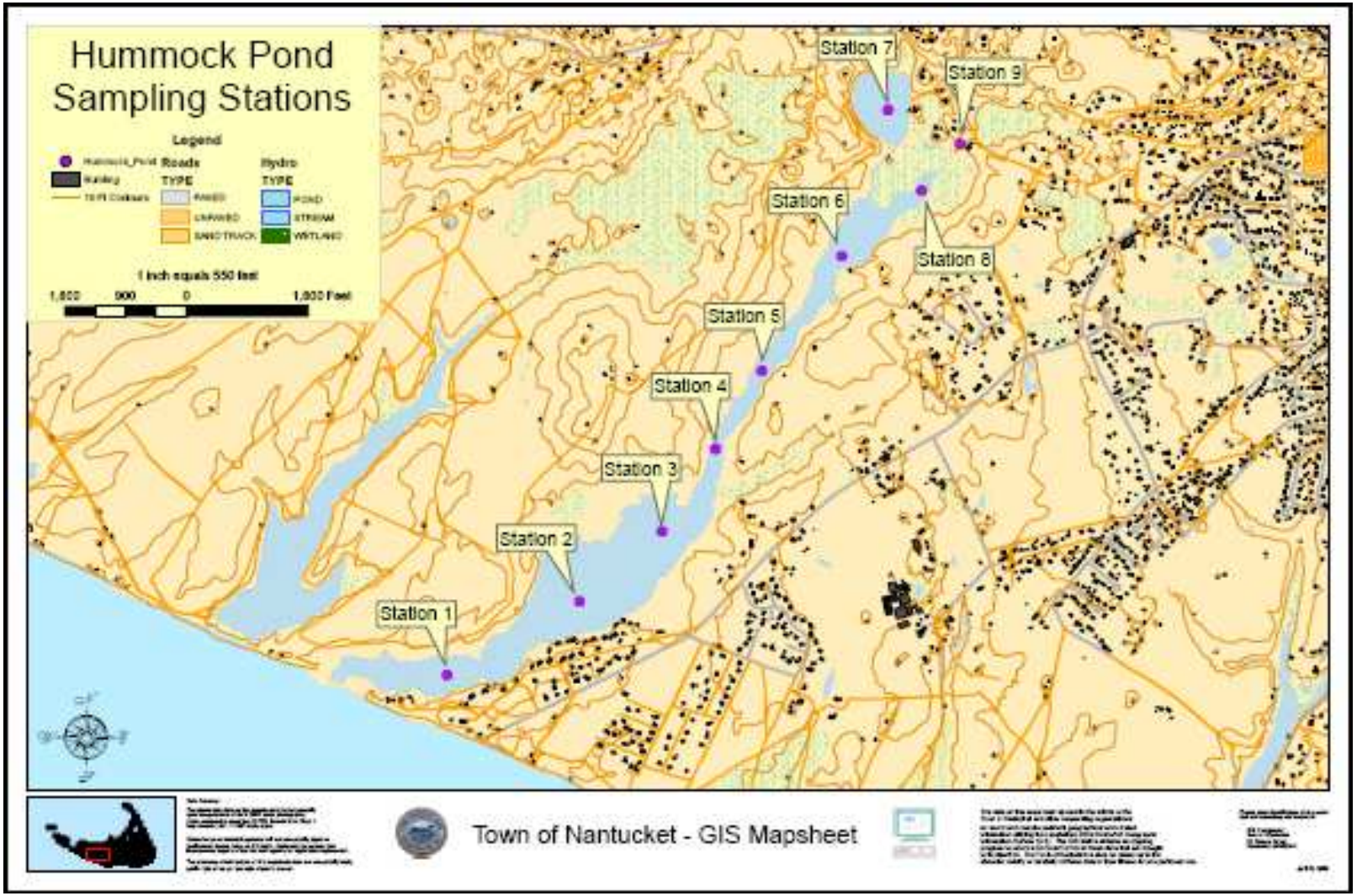

Figure 4. Hummock Pond sampling stations 2010.

Figure 5. Miacomet Pond sampling stations 2010.

Summary of 2010 Water Quality Results for Nantucket Sampling

Water samples collected from May through October in the estuarine systems generally showed that organic nitrogen (dissolved + particulate) dominated the Total Nitrogen pool (89%-98%), while bio-available nutrients in the form of nitrite and nitrate (NOx) and ammonium (NH_4) accounted for 2%-11% of Total Nitrogen (Table 2, Figure 6). That organic nitrogen is such a large part of the Total Nitrogen in these systems would indicate that they are effectively converting the bioavailable inorganic forms of nitrogen into organic forms (e.g. phytoplankton). Where tidal flushing is effective, much of this particulate matter along with dissolved nutrients is washed out of the system resulting in good water clarity as evidenced by the greater secchi depth readings in Nantucket Harbor and Madaket Harbor (Table 2). Corresponding Chlorophyll pigment concentrations were lowest in these well flushed systems (Table 2). Where tidal flushing is more restricted in Long, Hummock, Miacomet and Sesachacha Ponds, water clarity is relatively poor as shown by generally shallower Secchi Depth recordings and higher Chlorophyll pigment concentrations (Table 2).

Nitrogen data from the streams sampled in June showed a similar pattern with organic forms of N (DON and PON) accounting for 84%-97% of the TN and inorganic forms (DIN) 3%-16% (Table 2).

Average Total Nitrogen values ranged from 1.75 mg/L in Long Pond, 0.944 mg/L in Hummock Pond, 0.919 mg/L in Miacomet Pond, 0.704 mg/L in Sesachacha Pond, all relatively poorly flushed. Average TN levels in all 4 ponds are significantly higher than average values in the "offshore" stations NAN 4 and MH4 which average 0.302 and 0.285 mg/L, respectively (Table 2, Figures 1, 2).

Average TN level in Madaket Harbor (Stations 1-3, not including Station 4, offshore) was 0.462 mg/L, compared to the off-shore Station 4 (0.285 mg/L). Average TN in Nantucket Harbor (all Stations except Station 4, offshore) averaged 0.369 mg/L, compared to 0.302 mg/L at the off-shore Station 4 (Table 2). TN concentrations in the 6 streams adjacent to Nantucket Harbor ranged from 0.565 mg/L in Stream 8 to 2.139 mg/L in Stream 6B (Table 2). In spite of the high TN concentrations in these 6 streams and the likely high TN loads that these streams contribute to the Harbor, tidal flushing and dilution with lower concentration Harbor waters seems to be an effective mechanism to keep TN levels in the main body of the Harbor relatively low (Table 2, Figure 2). TN concentrations in Polpis Harbor, which is fed by the high TN levels in Streams 4, 6B and 6C, are somewhat higher than the levels in the main Harbor but still significantly lower than the levels in the streams themselves (Table 2, Figure 2).

Within Long, Hummock and Miacomet ponds, there is a general gradient of nutrient (N and P) and chlorophyll concentrations from high levels in the upper, more enclosed and poorly flushed reaches of the estuaries to lower concentrations closer to the outlets where flushing is more effective (Figure 6, Table 2). In Sesachacha Pond, there is no noticeable nutrient or chlorophyll gradient among any of the 4 Stations (Figure 6, Table 2). Madaket Harbor shows a small nutrient gradient (and a larger chlorophyll gradient) from Station 1 in Hither Creek (which receives discharge from Madaket Ditch), and is relatively poorly flushed, out to Station 2 in the Harbor. No significant gradient was observed within the Harbor itself from Station 2 out to the off-shore Station 4 (Figure 6, Table 2).

In Nantucket Harbor, there is a very small nutrient gradient from Wauwinet at the Head of the Harbor and the more enclosed Polpis stations out to the entrance at Stations 8 and 4 (Figure 6, Table 2). There is also a chlorophyll gradient with the highest concentrations at the 2 Polpis Stations (5 and 6), decreasing in the main Harbor and out to the off-shore Station 4 (Table 2).

In reviewing the 2010 dissolved oxygen data, we are concerned about the results at many of the sites sampled. Some of the values seem low and at some stations, there is a lack of a vertical profile. In Nantucket Harbor, for instance, there is no significant difference in dissolved oxygen values between Station 3 off of Wauwinet and the off-shore Station 4. Because of these concerns, we feel that there is a need to strengthen the dissolved oxygen data base for the future. We have made some recommendations which we have noted at the end of the discussion section.

Comparison of the 2010 data with historical data: At all sites, historical TN levels from previous years of sampling were compared to 2010 TN concentrations. Historical data presented here are from the Massachusetts Estuaries Project (MEP) reports for Nantucket Harbor, Sesachacha Pond and Madaket Harbor/Long Pond. Historical data for Hummock Pond 2007 and for Miacomet Pond 2005 are from the Annual Reports by the Nantucket Marine and Coastal Resource Department. Not all sites sampled historically were sampled in 2010 but those that were are compared to the historical data in Tables 3 through 6.
The 2010 Nantucket Harbor TN data generally compare well with historical data from the same or adjacent sites sampled by both SMAST and the Town from 1988 through 2005 (Figure 7, Table 3). Not all of the historical sites were sampled in 2010 (Table 3). At Station Town 3, the historical mean for TN was 0.401 $\pm$ 0.115 mg/L while the 2010 TN value is 0.392 mg/L. At Station 3A the historical mean for TN was 0.336 $\pm$ 0.112 mg/L. The 2010 TN value at the comparable Station Town 2 was 0.297 mg/L. In East Polpis Harbor the historical mean is 0.362 $\pm$ 0.112 mg/L while the 2010 value is 0.438 mg/L. In West Polpis, the historical mean is 0.388 $\pm$ 0.119 mg/L similar to that in East Polpis. The 2010 value for TN is 0.431, similar to the 2010 value in East Polpis. The historical mean value for TN in the mooring area (Stations 7, 1 and 1A) is 0.326 $\pm$ 0.106 mg/L. The 2010 TN concentration at Town Station 7 (comparable to 1A) is 0.377 mg/L. Finally the historical TN mean at the off-shore Station (OS and Town 4) is 0.239 $\pm$ 0.041 mg/L. The 2010 mean for TN is 0.302 mg/L.

In Sesachacha Pond, only Station 1 was available for comparison (Figure 8). The historical mean for TN was 1.197 $\pm$ 0.078 mg/L while in 2010 the value was less at 0.684 mg/L (Table 4).

In Madaket Harbor only MEP M11 and Town 1 were comparable sites. TN values agreed very well here. The historical mean was 0.620 $\pm$ 0.215 mg/L at M11 while the 2010 value was 0.626 mg/L (Table 5). The 2010 Stations 2 and 3 were distributed throughout the harbor between historical stations 3 and 10, and 10 and 2, respectively and 2010 Station 2 was located at the mouth of Hither Creek (Figure 9). TN values at these stations were comparable to values at the historical stations (Table 5).

In Long Pond, the historical value of TN at Station 2 was 0.971 $\pm$ 0.369 mg/L while the 2010 value at comparable Town Station 5 was 1.385 mg/L (Figure 9, Table 5). At historical Station 4, mean TN concentration was 0.894 $\pm$ 0.278 mg/L; the 2010 value at Town 6 was 2.044 mg/L. Both 2010 values are higher than the historical means but are reasonable in comparison given the variability in the historical data as evidenced by the standard deviation (s.d.) of the means (Table 5).

In Hummock Pond, 3 Stations have both 2007 and 2010 data from Town sampling programs, Stations 1, 3 and 7 (see Figure 4). At Station 1, the 2007 TN mean value was 0.751 ± 0.374 mg/L while the 2010 value was 0.616 mg/L (Table 6). For Station 3 (2007) the TN mean value was 0.630 ± 0.388 mg/L and the 2010 mean was 0.589 mg/L (Table 6). The Station 7 2007 mean for TN was 1.283 ± 0.969 mg/L while the 2010 value was 1.786 mg/L (Table 6). The 2010 data compare well with the 2007 data.

Town data for Miacomet Pond was available at all 3 Stations from 2005 and 2010 (see Figure 5). At Station 1, the 2005 mean TN concentration was 0.842 ± 0.191 mg/L and the 2010 value was 0.854 mg/L (Table 6). The Station 2 mean TN value was 0.855 ± 0.213 mg/L while the 2010 concentration was 0.811 mg/L (Table 6). Finally at Station 3 the lone 2005 value of TN was 0.280 mg/L. The 2010 value was 1.093 mg/L (Table 6). It is not clear why the lone TN value in 2005 was so low compared with the other Stations in the Pond but the 2010 and the historical data from the other 2 stations agree well.

Trophic State of the Estuaries of Nantucket Island

The Trophic State of an estuary is a quantitative indicator of its trophic health and is based on concentrations of Nitrogen, Secchi Depth, lowest measured concentrations of Dissolved Oxygen, and Chlorophyll pigments. Trophic health scales generally range from Oligotrophic (healthy) to Mesotrophic (showing signs of deterioration of health) to Eutrophic (unhealthy, deteriorated condition). The Trophic Health Index Score used here is a basic numerical scale based on criteria for open water embayments and uses the above mentioned measured parameters to create a habitat quality scale (Howes et al. 1999, http://www.savebuzzardsbay.org). For Nantucket, a trophic index score was calculated for all the sampled estuaries using the 2010 data (Table 7). As we stated earlier, because there is some concern about the dissolved oxygen data from 2010, we also calculated a trophic index for these same estuaries without the oxygen data (Table 8). The Health Status of each site was based on the Index Score, which is, in turn, based on the data collected during the sampling events. The ranges of Index scores that fall within a particular Health Status determination are given at the bottom of both Tables 7 and 8. Figures 10-14 show the Health Status of each of the 2010 sampling sites within the estuaries studied. Values calculated with the dissolved oxygen data are shown as upright triangles and values without the oxygen data are shown as inverted triangles. The colors of each triangle represent the Health Status of its site:

Color	**Health Status**
Blue	High Quality
Blue/Yellow	High-Moderate
Yellow	Moderate
Yellow/Red	Moderate/Fair
Red	Fair/Poor

Trophic Index scores changed (Madaket Harbor and Nantucket Harbor scores increased while the others decreased) when the dissolved oxygen data was eliminated from the calculation. If the score change was significant enough, the resulting Health Status also changed.

Madaket Harbor

The water with the poorest “health” status is in Hither Creek at Station 1 (Table 7, 8, Figure 10). With scores of 16.7 (including oxygen data) or 24.9 (without oxygen), Station 1 scored

the poorest of all the Madaket Harbor sampling sites in 2010. Scores for Stations 2-4 also increased when the oxygen data were eliminated (Tables 7, 8). Station 2 at the mouth of Hither Creek scored higher as the poor quality water from Hither Creek was diluted by cleaner open harbor water but was still classified as Moderate with or without the oxygen data. Station 3 scored High/Moderate when the oxygen data were included but was considered High when dissolved oxygen results were left out of the calculation (Figure 10, Tables 7, 8). Finally, the off-shore Station 4 scored High with or with out oxygen data (Figure 10, Tables 7, 8).

Long Pond

Both Long Pond Station Index scores decreased when the oxygen data were eliminated (Table 7,8). Water quality at both sampling sites in this poorly flushed sub-estuary to Madaket Harbor was poor. Station 5 scored as Moderate/Fair with the oxygen data but Fair/Poor without it. Station 6, further upstream, was classified as Fair/Poor with or without the oxygen data (Figure 10, Table 7, 8).

Nantucket Harbor

Trophic scores at all Stations increased when dissolved oxygen data were eliminated from the calculation (Table 7, 8). In general water quality is moderate at the Head of the Harbor off Wauwinet (Station 3), in Polpis East (Station 6) and West (Station 5), and off of the Town docks (Station 7), all adjacent to shore areas, streams, and/or are located in poorly flushed areas (Figure 11). When oxygen data are eliminated from the calculation of the trophic index score, the increase in scores at Stations 3 and 7 upgrade the Trophic Status at both sites from Moderate to High/Moderate (Table 7, 8, Figure11). Water quality improves away from these areas out toward mid-Harbor (Stations 1 and 2) or offshore (Stations 8 and 4) where tidal flushing is significant (Table 7, 8, Figure 11). The health status of these sites remains high with or without the oxygen data in the calculation.

Sesachacha Pond

At all stations in Sesachacha Pond, which is isolated from the ocean most of the year but periodically opened for flushing, scores decrease slightly when oxygen data are not included in the calculation of the trophic index (Table 7, 8). Water quality at Stations 1, 2 and 4 is moderate with oxygen data included while Station 3 is Moderate/Fair (Table 7, Figure 12). When oxygen data are eliminated, the health status of Stations 1, 3 and 4 remains the same while that of Station 2 is down-graded to Moderate/Fair (Table 8, Figure 12).

Hummock Pond

Without dissolved oxygen data, Trophic scores decrease slightly (Figure 7, 8) but not enough to change the health status at any of the sampling stations (Table 7, 8, Figure 13). The health of the pond is Fair/Poor in the upper reaches at Stations 5, 7 and 8 (Figure 13), improving slightly to Moderate/Fair further downstream at Station 3 and then to Moderate at Station 1 nearest the mouth of the estuary (Figure 13). Poor flushing helps to maintain degraded conditions here throughout the estuary.

Miacomet Pond

As is the case with most of the estuaries in this study, trophic index scores decrease when oxygen data are not included in the calculation Table 7, 8). With dissolved oxygen in the calculation, the Health Status of Stations 1 and 2 is Moderate/Fair while the upper-most Station 3 is Fair/Poor. Without oxygen, the health scores of Stations 1 and 2 decrease enough to degrade the health status to Fair/Poor; the health score of Station 3 also decreases but the status remains Fair/Poor. Like other degraded estuaries on Nantucket, poor flushing

prevents nutrients and particulate matter entering the system via adjacent terrestrial sources from being washed out by the tides and maintains poor water quality throughout.

Recommendations for Monitoring

As stated earlier, because of our concern about the dissolved oxygen data from the 2010 monitoring program and because dissolved oxygen in the water column, especially bottom waters which are subject to periodic episodes of hypoxia/anoxia, is such an important component in structuring aquatic ecosystems, we feel that steps should be taken to strengthen the oxygen data base in Nantucket's estuaries.

Two possible approaches that could help to accomplish this end are:

1) Running Winkler Titrations on water samples where meter readings of D.O. are < 5mg/L. Winkler titration is a more accurate and precise method for quantifying dissolved oxygen concentrations in samples expected to have low DO levels,

2) Deploying in situ oxygen meters (sondes) on the bottom of specific estuaries at several strategic locations for the summer months when periodic hypoxic or anoxic events in bottom waters can occur.

Station ID	Secchi Depth (m)	Secchi Depth as % WC	20% Low D.O. (mg/L)	20% Low % Sat	Salinity ppt	PO4 mg/L	NH4 mg/L	NOX mg/L	DIN mg/L	DON mg/L	PON mg/L	TON mg/L	TN mg/L	Total Pig (ug/L)
HUM1	1.4	54.4%	4.81	56.0%	7.3	0.013	0.021	0.002	0.023	0.425	0.168	0.592	0.616	12.30
HUM3	1.3	61.5%	4.99	59.8%	6.4	0.012	0.022	0.003	0.025	0.380	0.184	0.564	0.589	11.04
HUM5	0.9	44.2%	4.65	56.1%	5.3	0.015	0.020	0.003	0.023	0.430	0.313	0.743	0.766	27.03
HUM7	0.9	23.4%	3.89	45.0%	4.0	0.284	0.070	0.069	0.139	0.628	1.020	1.647	1.786	67.66
HUM8	0.7	51.0%	4.80	56.5%	4.4	0.025	0.031	0.008	0.039	0.584	0.360	0.944	0.983	33.02
LONG5	0.6	48.5%	4.77	62.9%	16.0	0.071	0.009	0.002	0.011	0.480	0.894	1.374	1.385	18.08
LONG6	0.6	48.8%	4.76	62.9%	15.9	0.028	0.022	0.003	0.026	0.567	1.452	2.019	2.044	24.21
MH1	1.6	67.1%	3.00	40.1%	26.8	0.024	0.045	0.005	0.050	0.316	0.260	0.576	0.626	14.20
MH2	1.9	93.9%	3.52	47.9%	29.7	0.014	0.024	0.003	0.027	0.264	0.145	0.409	0.436	9.37
MH3	2.3	100.0%	4.39	55.5%	30.8	0.011	0.024	0.002	0.026	0.213	0.084	0.297	0.324	6.14
MH4	3.8	58.3%	4.27	55.6%	31.1	0.015	0.024	0.002	0.026	0.190	0.069	0.259	0.285	4.21
MP1	1.5	86.3%	5.43	54.0%	0.7	0.003	0.030	0.002	0.032	0.557	0.265	0.822	0.854	16.29
MP2	1.9	58.5%	5.70	62.8%	0.6	0.002	0.044	0.002	0.046	0.554	0.210	0.764	0.811	11.50
MP3	1.3	83.1%	4.93	56.6%	0.1	0.031	0.048	0.056	0.104	0.499	0.490	0.990	1.093	51.52
NAN1	4.5	84.8%	3.57	48.2%	31.0	0.016	0.027	0.003	0.030	0.218	0.084	0.302	0.332	4.00
NAN2	3.4	62.8%	3.45	47.4%	31.0	0.018	0.016	0.003	0.019	0.201	0.077	0.278	0.297	5.36
NAN3	2.8	49.2%	3.72	52.4%	30.9	0.022	0.027	0.003	0.030	0.251	0.111	0.362	0.392	7.58
NAN4	3.7	84.5%	3.89	52.2%	29.8	0.015	0.027	0.002	0.029	0.203	0.070	0.273	0.302	4.15
NAN5	2.0	98.0%	3.18	44.3%	30.4	0.017	0.027	0.007	0.034	0.248	0.149	0.397	0.431	11.31
NAN6	2.2	88.7%	3.26	45.7%	30.5	0.016	0.024	0.004	0.028	0.277	0.133	0.410	0.438	10.31
NAN7	2.1	92.5%	3.60	49.8%	30.9	0.016	0.023	0.003	0.026	0.244	0.106	0.351	0.377	7.35
NAN8	2.4	100.8%	3.65	50.0%	31.1	0.018	0.031	0.002	0.033	0.204	0.076	0.280	0.313	3.93
SESA1	1.6	32.9%	4.82	56.4%	11.9	0.051	0.018	0.003	0.021	0.441	0.222	0.663	0.684	8.00
SESA2	1.4	28.6%	4.83	56.4%	11.9	0.045	0.024	0.003	0.027	0.469	0.219	0.688	0.715	7.19
SESA3	1.5	36.6%	4.83	56.2%	11.9	0.049	0.021	0.006	0.028	0.449	0.223	0.672	0.700	7.61
SESA4	1.5	38.7%	4.83	56.4%	11.9	0.046	0.024	0.003	0.027	0.470	0.221	0.691	0.718	6.73
82 WAUWINET	ND	ND	ND	ND	18.2	0.071	0.122	0.004	0.126	0.611	0.108	0.719	0.845	40.70
STREAM1	ND	ND	ND	ND	0.3	0.077	0.081	0.021	0.102	1.419	0.258	1.677	1.779	2.64
STREAM4	ND	ND	ND	ND	<0.1	0.163	0.039	0.008	0.048	1.092	0.061	1.153	1.200	1.18
STREAM6B	ND	ND	ND	ND	<0.1	0.006	0.059	0.004	0.064	1.701	0.374	2.076	2.139	16.37
STREAM6C	ND	ND	ND	ND	<0.1	0.132	0.097	0.003	0.100	0.375	0.156	0.532	0.632	7.41
STREAM8	ND	ND	ND	ND	3.3	0.015	0.045	0.005	0.050	0.398	0.118	0.516	0.565	5.29

Secchi as % of WC is the % of the water column above the secchi depth, values of 100% means that the Secchi was at or below the bottom.
Lowest 20% of D.O. records for a site over the project period.

HUM = Hummock Pond, Long = Long Pond, MH = Madaket Harbor, MP = Miacomet Pond, NAN = Nantucket Harbor, SESA = Sesachacha Pond

Table 2. Summary of Water Quality Parameters, 2010 Nantucket Sampling Program. Values are Station Averages of all sampling events, May-October for estuarine and harbor sites. Stream sites were sampled once in June (see Table 1).

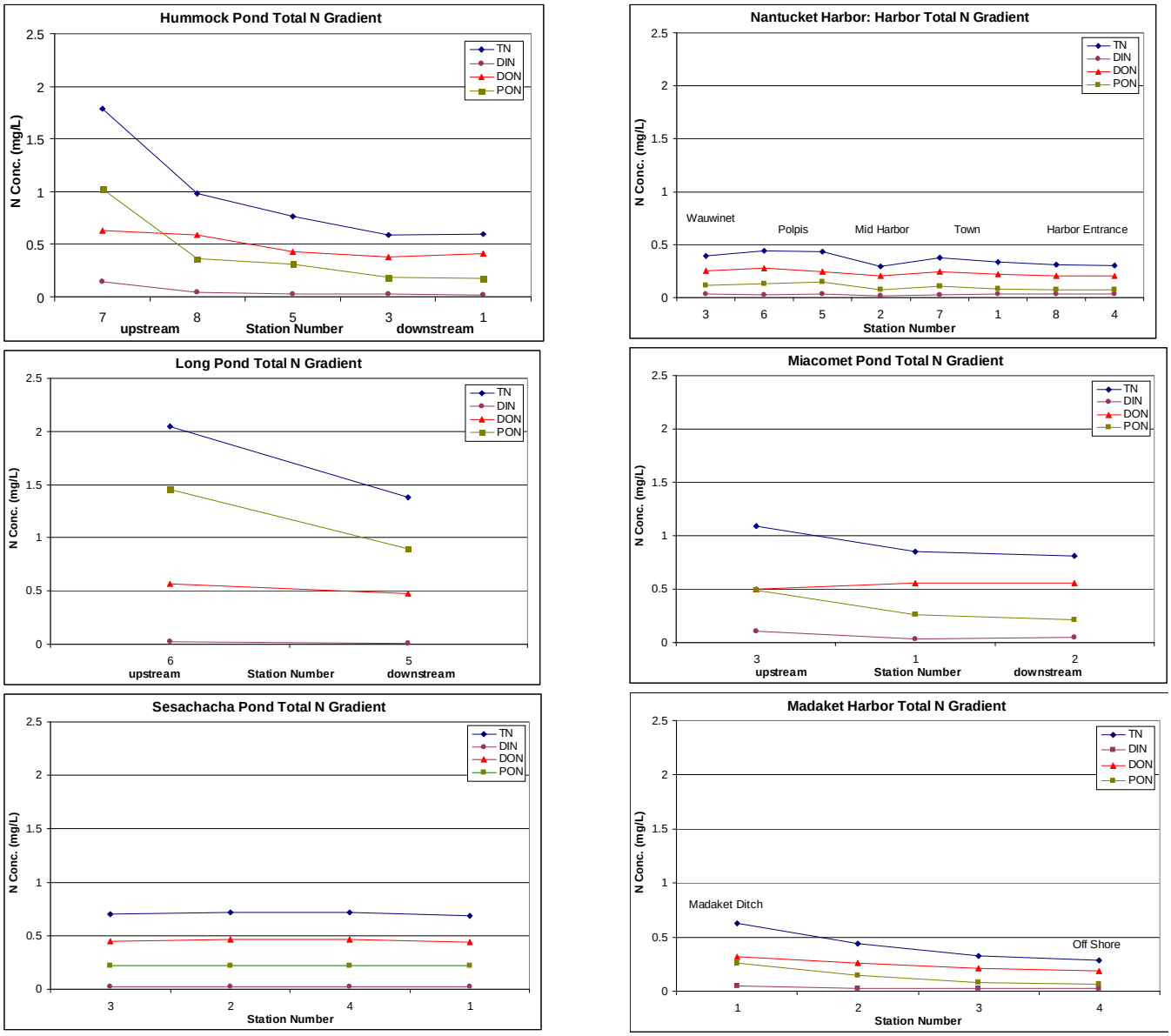

Figure 6. Comparison of nitrogen species in the Nantucket estuaries

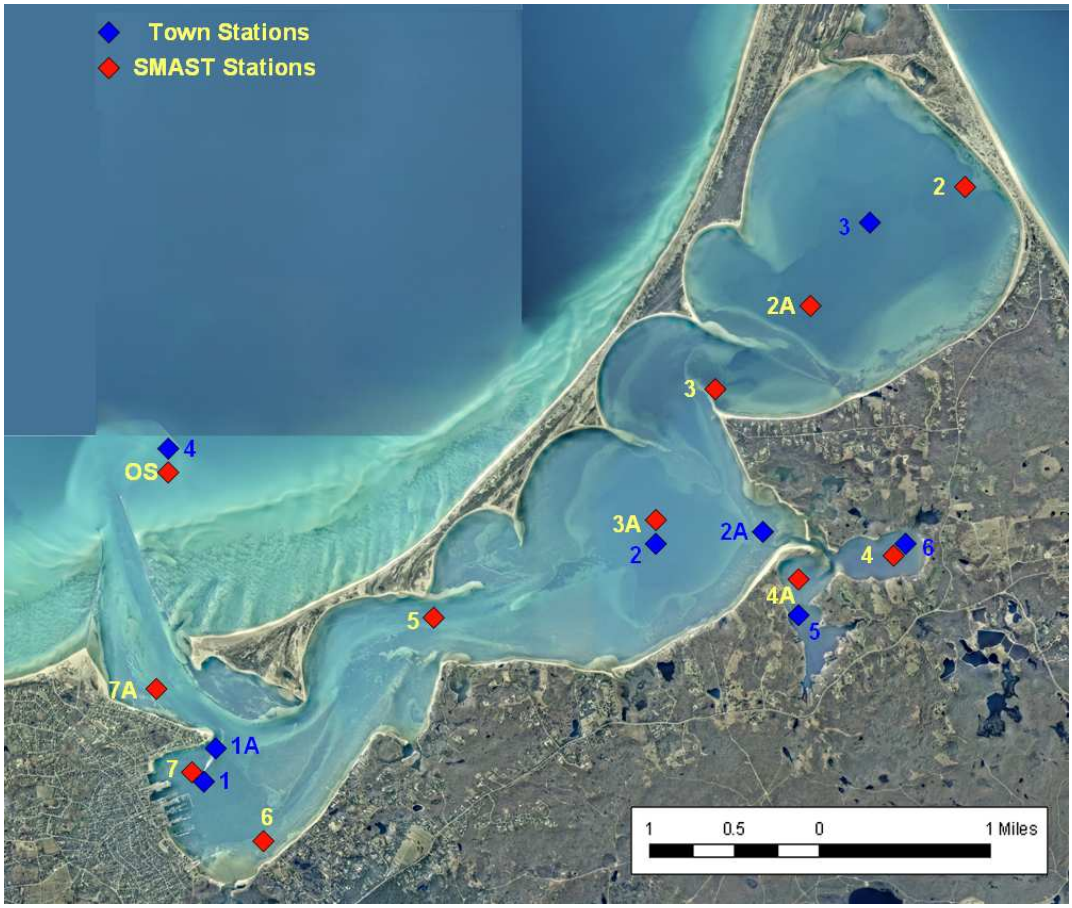

Figure 7. Estuarine water quality monitoring station locations in the Nantucket Harbor estuary system. Station labels correspond to those provided in Table 3 below. Red diamonds indicate locations of MEP monitoring stations. Blue diamonds show locations of Town sampling sites.

Sub-Embayment	monitoring station	Historical MEP Mean TN (mg/L)	s.d.	2010 Town ID	2010 Mean TN (mg/L)
Head of the Harbor - Upper	2	0.408	0.188	NA	Not Sampled
Head of the Harbor - Mid	Town 3	0.401	0.115	3	0.392
Head of the Harbor - Lower	2A	0.339	0.070	NA	Not Sampled
Pocomo Head	3	0.335	0.081	NA	Not Sampled
Quaise Basin	3A+Town 2	0.336	0.112	2	0.297
East Polpis Harbor	4+Town 6	0.362	0.105	6	0.438
West Polpis Harbor	4A+Town 5	0.388	0.119	5	0.431
Abrams Point	5	0.335	0.060	NA	Not Sampled
Monomoy	6	0.297	0.086	NA	Not Sampled
Mooring Area	7+Town 1,1A	0.326	0.106	1, 7	0.377
Nantucket Sound	OS+Town 4	0.239	0.041	4	0.302

. **Table 3.** Comparison of MEP mean values of TN with Town TN data (all values are mg/L) from Nantucket Harbor. MEP data were collected in the summers of 1988 through 1990 and 1992 though 1994 by the Woods Hole Oceanographic Institution (WHOI), and between 1992 and 2005 by the Town of Nantucket Marine Department. Town data were collected in the summer of 2010 by the Town of Nantucket Marine Department

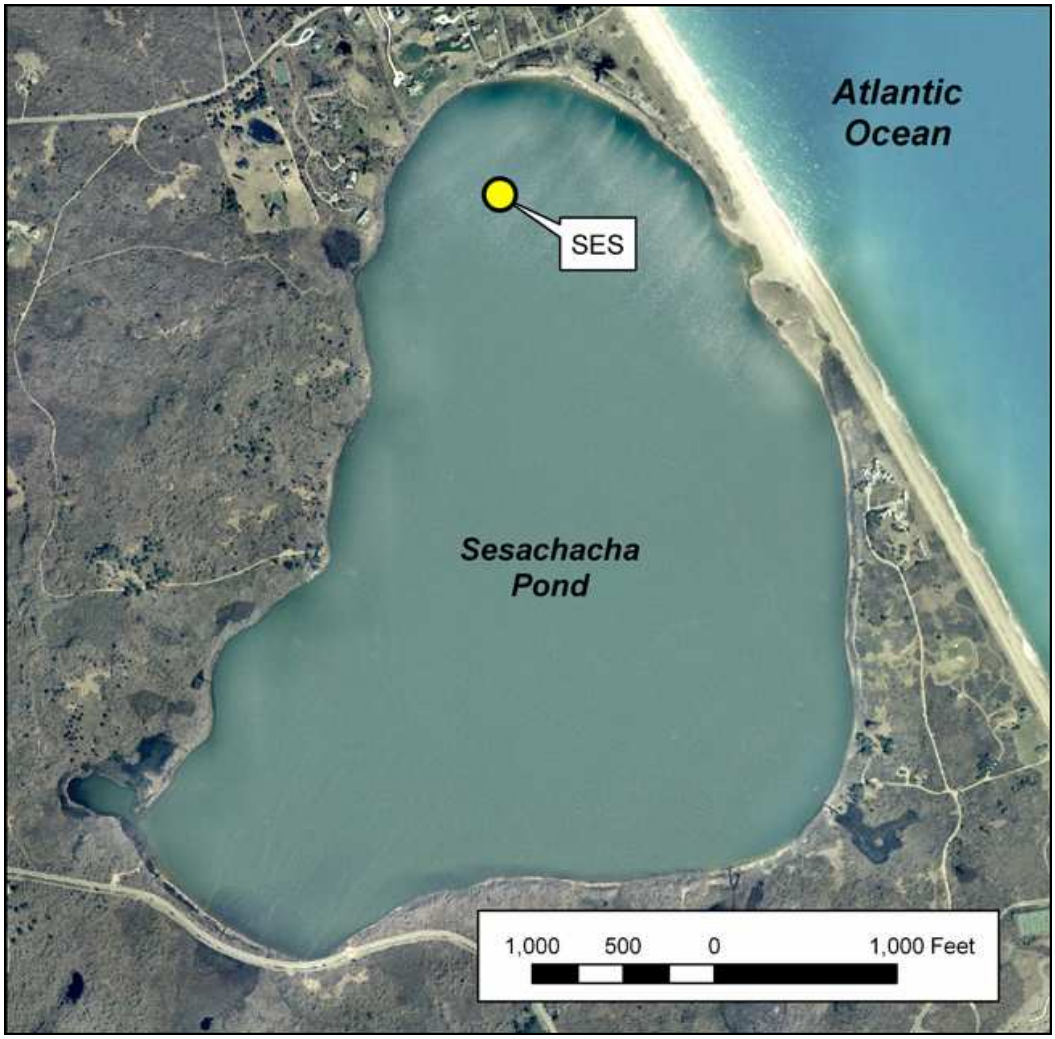

Figure 8. 2005 aerial photo showing MEP monitoring station location in Sesachacha Pond that was used in the water quality analysis.

Sampling Station Location	Historical MEP Mean TN (mg/L)	s.d.	2010 Mean TN (mg/L)
Sesachacha Pond	1.197	0.078	0.684

Table 4. Comparison of MEP mean values of TN with Town TN data (all values are mg/L) from Sesachacha Pond. MEP data were collected in the summers of 1992 through 2005. Town data were collected in the summer of 2010 by the Town of Nantucket Marine Department.

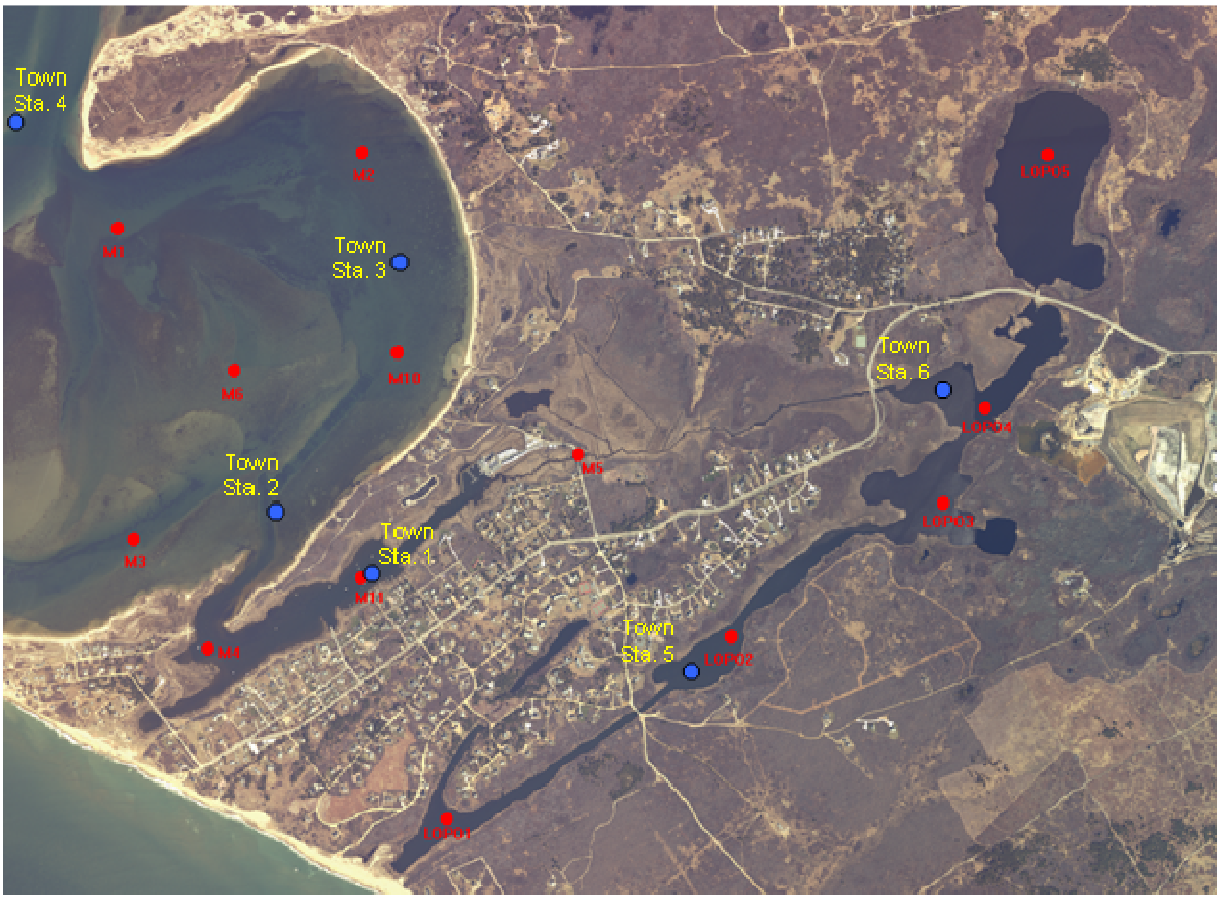

Figure 9. Estuarine water quality monitoring station locations in the Madaket Harbor and Long Pond Systems.

Sub-Embayment	Monitoring station	Historical MEP Mean TN (mg/L)	s.d.	2010 Mean TN (mg/L)
Madaket Harbor	MEP M1	0.336	0.098	
Madaket Harbor	Town 4			0.285
Madaket Harbor	MEP M2	0.395	0.083	
Madaket Harbor	Town 2			0.436
Madaket Harbor	MEP M3	0.415	0.090	
Madaket Harbor	Town 3			0.324
Hither Creek	MEP M4	0.581	0.193	
Hither Creek	MEP M5	0.780	0.178	
Madaket Harbor	MEP M6	0.347	0.067	
Madaket Harbor	MEP M10	0.422	0.127	
Hither Creek	MEP M11+Town 1	0.620	0.215	0.626
Long Pond	MEP LOPO1	1.058	0.404	
Long Pond	MEP LOPO2+Town 5	0.971	0.369	1.385
Long Pond	MEP LOPO3	0.924	0.234	
Long Pond	MEP LOPO4+Town 6	0.894	0.278	2.044
North Head Long Pond	MEP LOPO5	0.954	0.271	

Table 5. Comparison of MEP mean values of TN with Town TN data (all values are mg/L) from Madaket Harbor and Long Pond. MEP data were collected by SMAST in the summers of 2002 through 2004. Town data were collected in the summer of 2010 by the Town of Nantucket Marine Department.

Station ID	2010	2005/2007	
	TN (mg/L)	TN (mg/L)	
	Mean	Mean	S.D.
HUM1	0.616	0.751**	0.374
HUM3	0.589	0.630**	0.388
HUM5	0.766	ND	ND
HUM7	1.786	1.283**	0.969
HUM8	0.983	ND	ND
MP1	0.854	0.842*	0.191
MP2	0.811	0.855*	0.213
MP3	1.093	0.280*	0
***2005 data only** ****2007 data only**			

Table 6. Comparison of TN concentrations collected in 2005 (Miacomet Pond) and 2007 (Hummock Pond) by Nantucket Marine Department with Town TN data collected at both sites the summer of 2010. All values are mg/L.

ID	Secchi SCORE	Low20% Oxsat SCORE	DIN SCORE	TON SCORE	T-Pig SCORE	EUTRO Index	Health Status
HUM1	54.0	41.6	100.0	4.3	2.4	40.4	Moderate
HUM3	48.5	49.6	75.2	8.2	0.0	36.3	Moderate-Fair
HUM5	25.9	41.7	77.7	0.0	0.0	29.0	Fair-Poor
HUM7	22.4	14.5	0.4	0.0	0.0	7.4	Fair-Poor
HUM8	12.2	42.6	55.2	0.0	0.0	22.0	Fair-Poor
LONG5	0.6	55.8	100.0	0.0	0.0	31.3	Moderate-Fair
LONG6	4.6	55.8	73.9	0.0	0.0	26.8	Fair-Poor
MH1	59.0	0.3	44.5	5.4	0.0	21.8	Fair-Poor
MH2	72.8	22.3	70.7	50.3	5.4	44.3	Moderate
MH3	83.3	40.5	72.7	92.1	40.5	65.8	High-Moderate
MH4	100.0	40.5	72.4	100.0	71.8	77.0	High
MP1	54.8	37.1	63.7	0.0	0.0	31.1	Moderate-Fair
MP2	70.3	55.6	47.9	0.0	0.0	34.8	Moderate-Fair
MP3	47.1	42.8	12.9	0.0	0.0	20.6	Fair-Poor
NAN1	100.0	23.0	66.7	90.1	76.1	71.2	High
NAN2	100.0	20.9	87.2	100.0	51.8	72.0	High
NAN3	95.5	33.4	66.4	66.3	23.0	56.9	Moderate
NAN4	100.0	32.8	68.0	100.0	73.0	74.8	High
NAN5	74.8	12.5	62.1	54.1	0.0	40.7	Moderate
NAN6	81.7	16.6	69.8	49.9	0.0	43.6	Moderate
NAN7	78.1	27.1	72.3	70.4	25.6	54.7	Moderate
NAN8	86.7	27.5	62.3	100.0	77.6	70.8	High
SESA1	62.1	42.3	82.2	0.0	18.5	41.0	Moderate
SESA2	54.3	42.3	71.4	0.0	27.4	39.1	Moderate
SESA3	55.9	42.0	70.2	0.0	22.7	38.2	Moderate-Fair
SESA4	54.8	42.5	71.3	0.0	32.9	40.3	Moderate
High Quality = >69; High/Moderate = 61-69; Moderate = 39-61; Moderate/Fair = 31-39; Fair/Poor = <31							

Table 7. Trophic Health Index Scores and status for water quality monitoring stations in Nantucket estuaries based upon open water embayment (not salt marsh) habitat quality scales (described in Howes et. al., 1999 at www.savebuzzardsbay.org).

ID	Secchi SCORE	DIN SCORE	TON SCORE	T-Pig SCORE	EUTRO Index	Health Status
HUM1	54.0	100.0	4.3	2.4	40.1	Moderate
HUM3	48.5	75.2	8.2	0.0	33.0	Moderate-Fair
HUM5	25.9	77.7	0.0	0.0	25.9	Fair-Poor
HUM7	22.4	0.4	0.0	0.0	5.7	Fair-Poor
HUM8	12.2	55.2	0.0	0.0	16.9	Fair-Poor
LONG5	0.6	100.0	0.0	0.0	25.2	Fair-Poor
LONG6	4.6	73.9	0.0	0.0	19.6	Fair-Poor
MH1	59.0	44.5	5.4	0.0	27.2	Fair-Poor
MH2	72.8	70.7	50.3	5.4	49.8	Moderate
MH3	83.3	72.7	92.1	40.5	72.1	High
MH4	100.0	72.4	100.0	71.8	86.1	High
MP1	54.8	63.7	0.0	0.0	29.6	Fair-Poor
MP2	70.3	47.9	0.0	0.0	29.6	Fair-Poor
MP3	47.1	12.9	0.0	0.0	15.0	Fair-Poor
NAN1	100.0	66.7	90.1	76.1	83.3	High
NAN2	100.0	87.2	100.0	51.8	84.7	High
NAN3	95.5	66.4	66.3	23.0	62.8	High-Moderate
NAN4	100.0	68.0	100.0	73.0	85.3	High
NAN5	74.8	62.1	54.1	0.0	47.8	Moderate
NAN6	81.7	69.8	49.9	0.0	50.4	Moderate
NAN7	78.1	72.3	70.4	25.6	61.6	High-Moderate
NAN8	86.7	62.3	100.0	77.6	81.7	High
SESA1	62.1	82.2	0.0	18.5	40.7	Moderate
SESA2	54.3	71.4	0.0	27.4	38.3	Moderate-Fair
SESA3	55.9	70.2	0.0	22.7	37.2	Moderate-Fair
SESA4	54.8	71.3	0.0	32.9	39.8	Moderate
High Quality = >69; High/Moderate = 61-69; Moderate = 39-61; Moderate/Fair = 31-39; Fair/Poor = <31						

Table 8. Trophic Health Index Scores and status for water quality monitoring stations in Nantucket estuaries based upon open water embayment (not salt marsh) habitat quality scales. Index calculated without Dissolved Oxygen data (described in Howes et. al., 1999 at www.savebuzzardsbay.org).

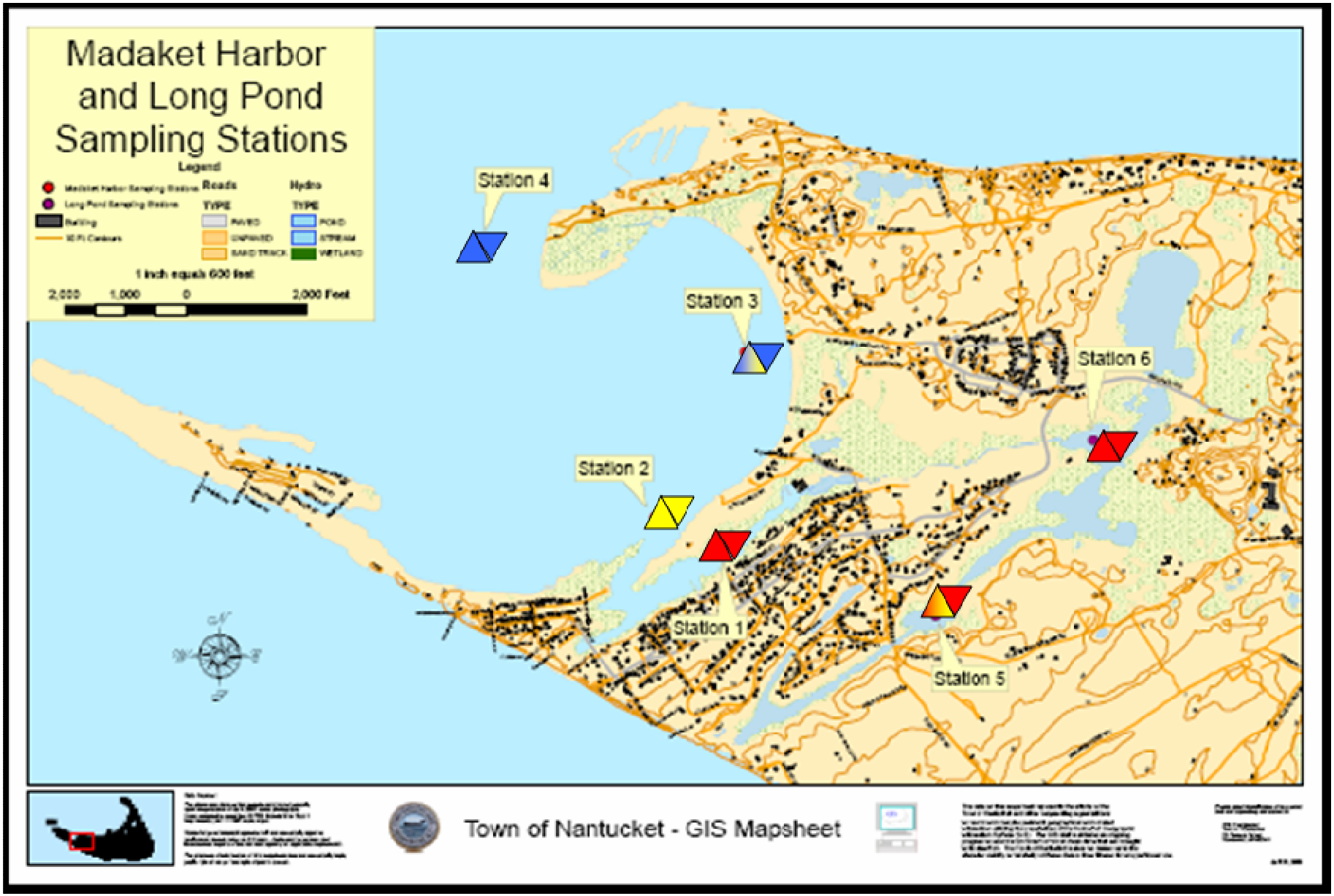

Figure 10. Madaket Harbor Eutrophication Index 2010.

Figure 11. Nantucket Harbor Eutrophication Index 2010.

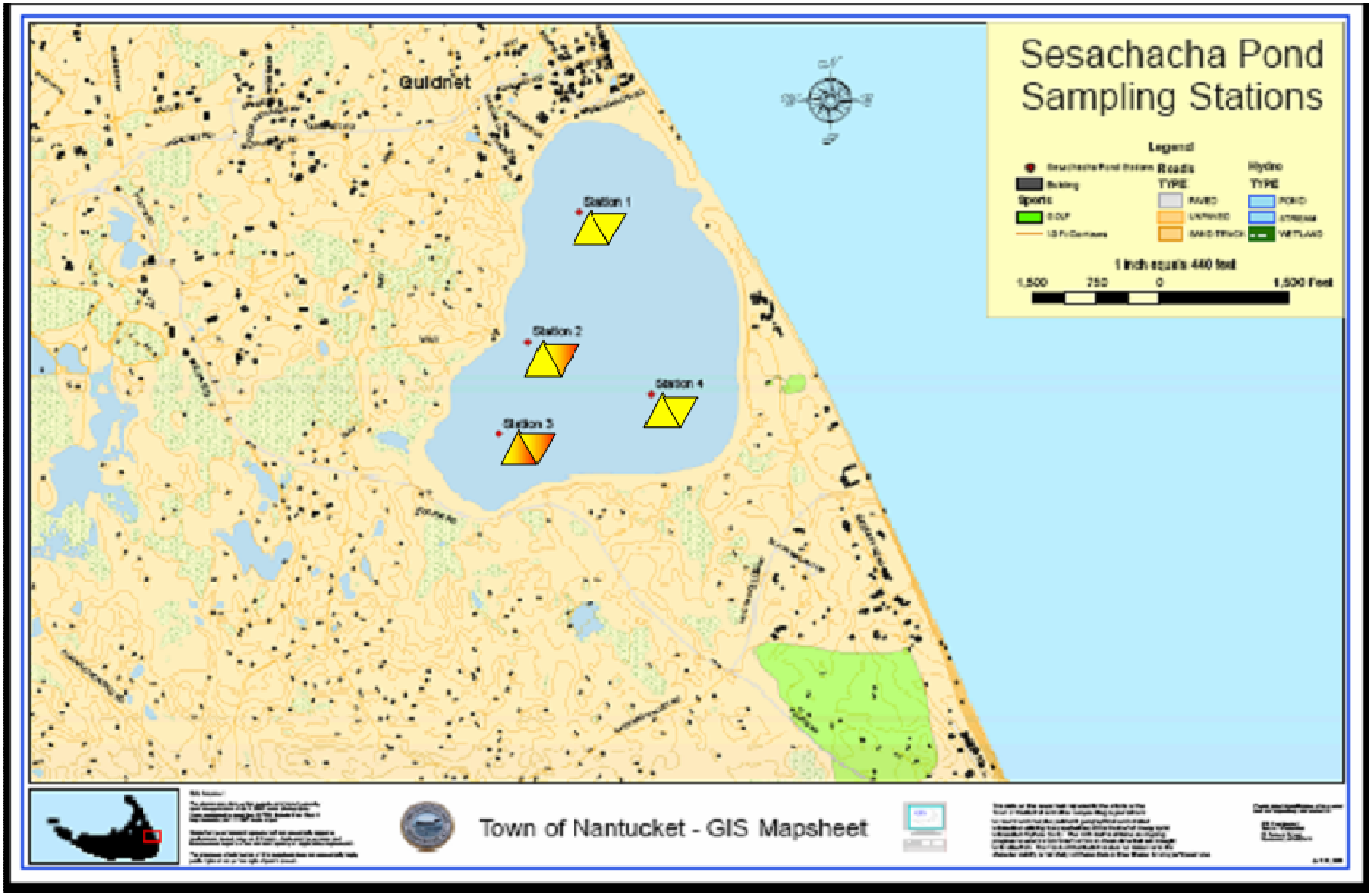

Figure 12. Sesachacha Pond Eutrophication Index 2010.

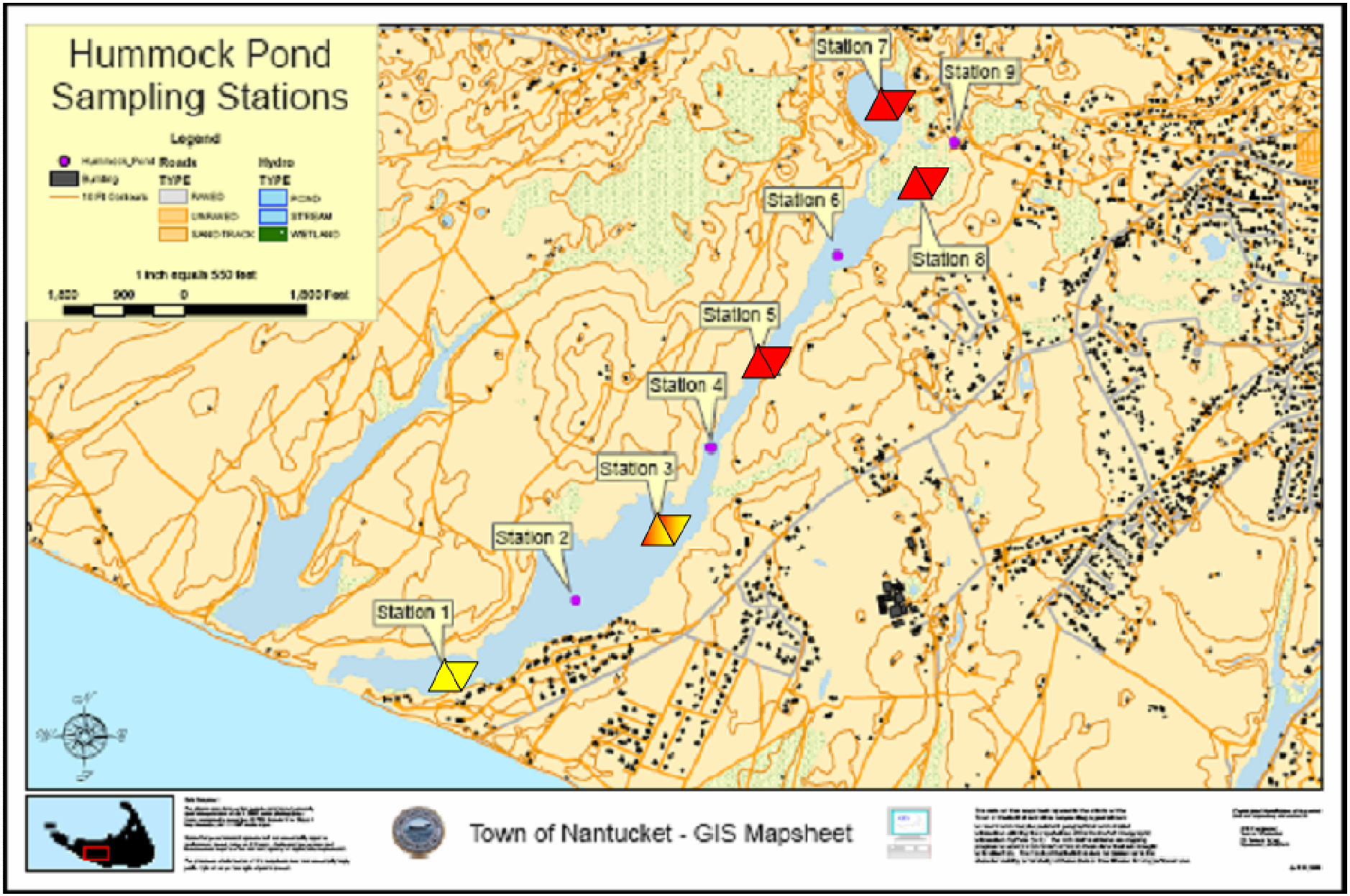

Figure 13. Hummock Pond Eutrophication Index 2010.

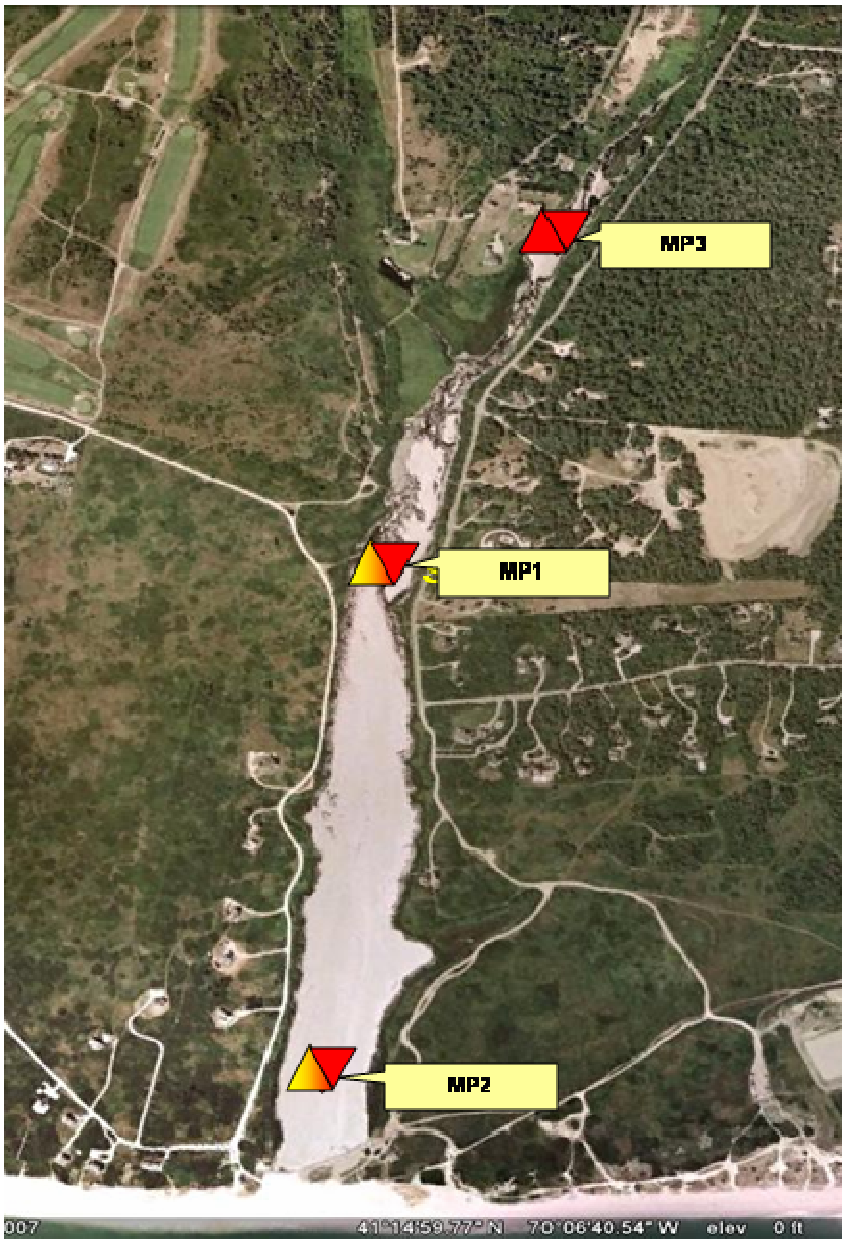

Figure 14. Miacomet Pond Eutrophication Index 2010.